

# CLARREO Roadmap

Climate Absolute Radiance & Refractivity Observatory

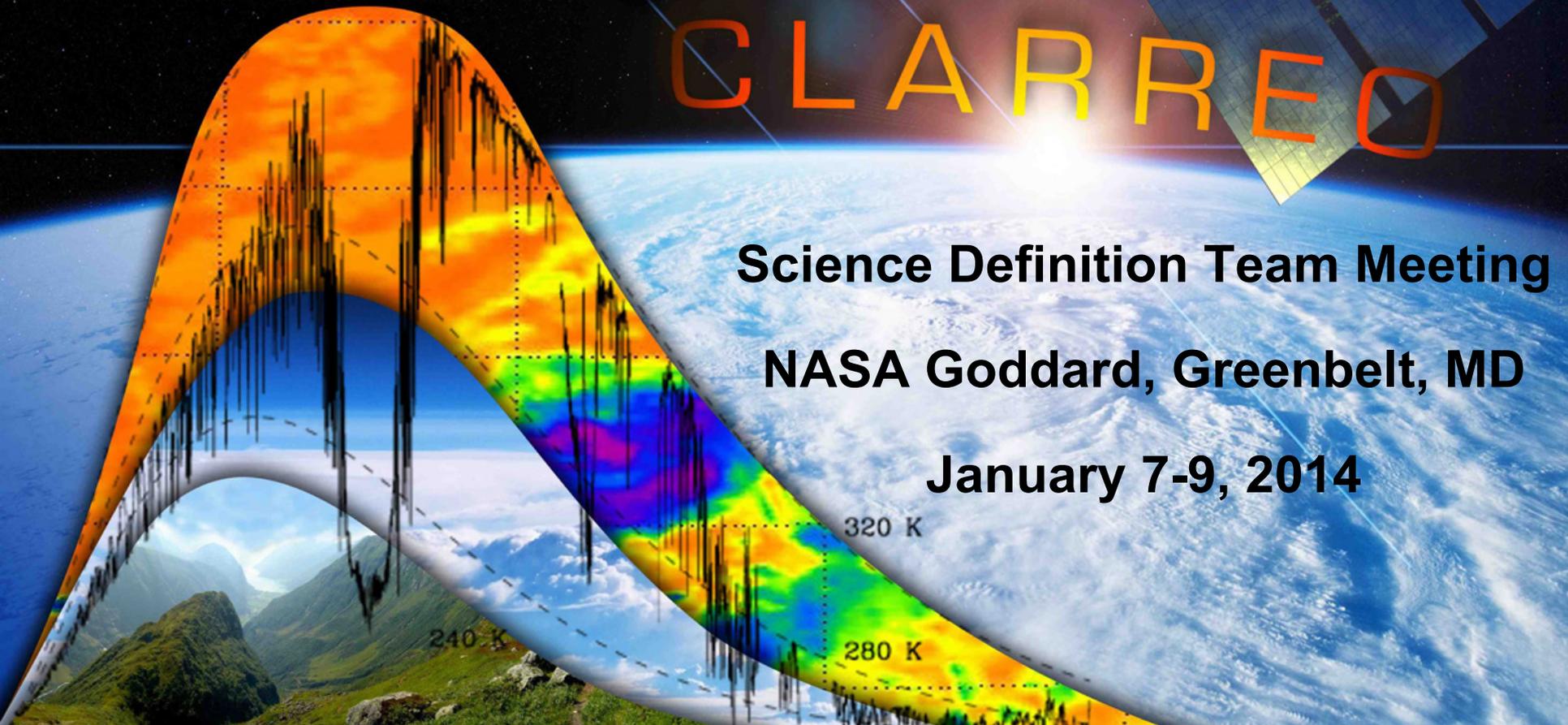
Bruce Wielicki and Rosemary Baize

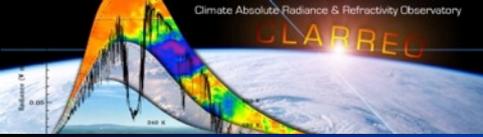
The logo for CLARREO is displayed in large, stylized letters. The 'C' is orange, 'L' is yellow, 'A' is yellow, 'R' is yellow, 'R' is yellow, 'E' is orange, and 'O' is orange. The letters are set against a background of a satellite in space and a view of Earth from space.

Science Definition Team Meeting

NASA Goddard, Greenbelt, MD

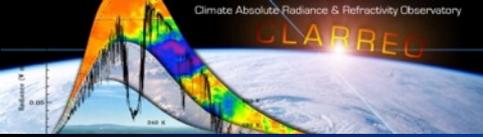
January 7-9, 2014





# CLARREO Mission Status

- Passed Mission Concept Review Nov 2010
- Science Definition Team selected in Jan 2011
- NASA Earth Science budget reduction in Feb 2011 has caused a delay.
- Remains in pre-phase A studies, no current launch date
- 2 RS and 2 IR instrument calibration demonstration systems underway (CU-LASP/GSFC for RS, UW/LaRC for IR)
- Climate Model OSSEs and Intercalibration simulation studies
- Alternative less costly mission studies: ISS best option to date
- International collaboration options with UK, Italy in study
- *No climate observing system: factor of 3 to 4 underfunded*



# 2013 Progress: Journals

- 26 journal papers published/in press in 2013
- 15 papers submitted/in review
- 42 papers in preparation
- 13 journal papers were published in 2012
- This SDT meeting will give us a fresh view of science study progress and directions

# CLARREO Mission BAMS Cover Paper



Volume 94 Number 10 October 2013

# BAMS

Bulletin of the American Meteorological Society

POLLUTION FROM WILDFIRES

GLOBAL CLOUD DATASETS

WEATHER DATA FROM CARS

## A MEASURE FOR MEASURES



In-Orbit Calibration of Climate-Change Monitoring

## ACHIEVING CLIMATE CHANGE ABSOLUTE ACCURACY IN ORBIT

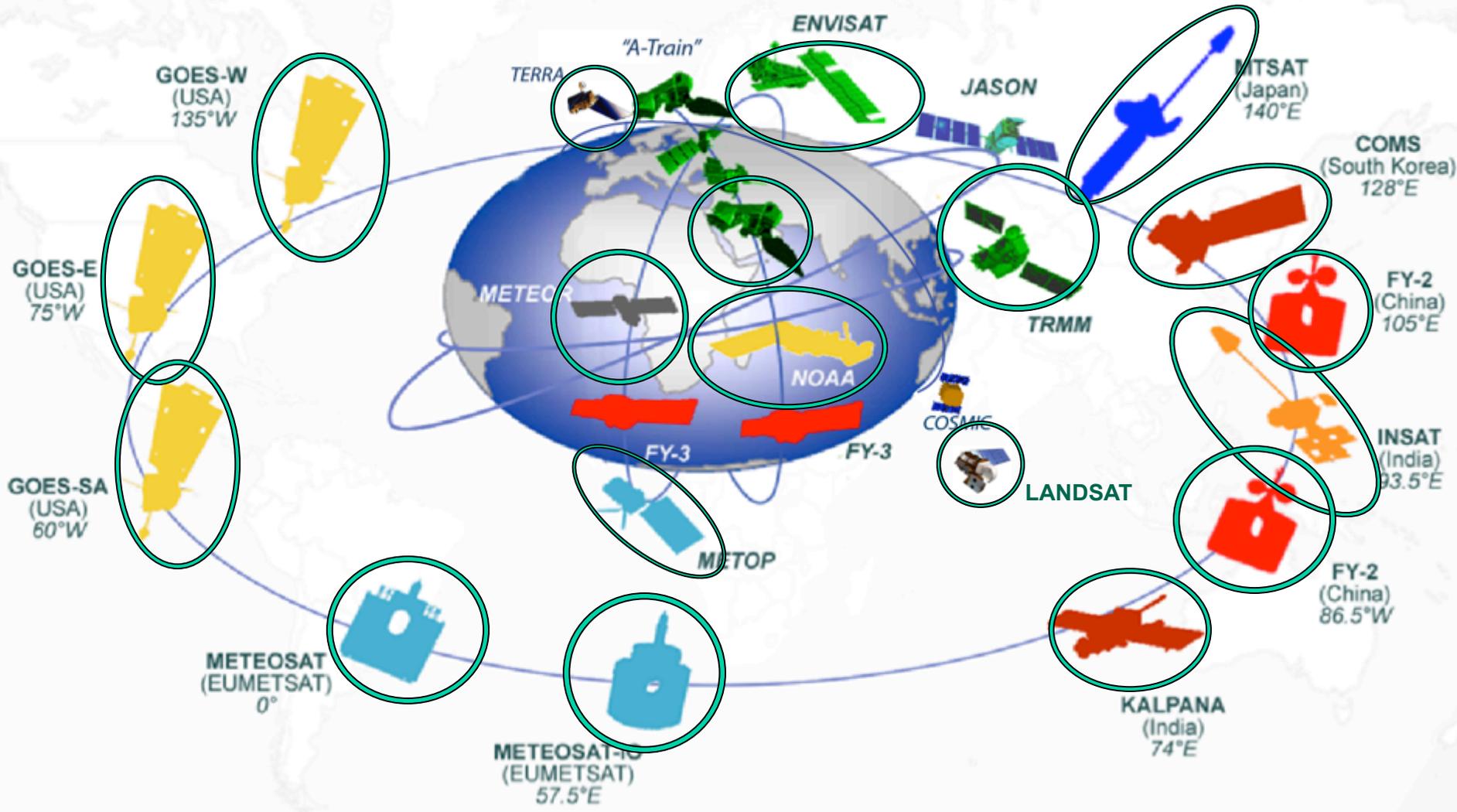
BY BRUCE A. WIELICKI, D. F. YOUNG, M. G. MLYNČZAK, K. J. THOME, S. LEROY, J. CORLISS, J. G. ANDERSON, C. O. AO, R. BANTGES, F. BEST, K. BOWMAN, H. BRINDLEY, J. J. BUTLER, W. COLLINS, J. A. DYKEMA, D. R. DOELLING, D. R. FELDMAN, N. FOX, X. HUANG, R. HOLZ, Y. HUANG, Z. JIN, D. JENNINGS, D. G. JOHNSON, K. JUICKS, S. KATO, D. B. KIRK-DAVIDOFF, R. KNUTSON, G. KOPP, D. P. KRATZ, X. LIU, C. LUKASHIN, A. J. MANNUCCI, N. PHOJANAMONGKOLKIJ, P. PILEWSKIE, V. RAMASWAMI, H. REVERCOMB, J. RICE, Y. ROBERTS, C. M. ROITHMAYR, F. ROSE, S. SANDFORD, E. L. SHIRLEY, W. L. SMITH SR., B. SODEN, P. W. SPETH, W. SUN, P. C. TAYLOR, D. TOBIN, AND X. XIONG

With its unprecedented accuracy, the Climate Absolute Radiance and Refractivity Observatory substantially shortens the time to detect the magnitude of climate change at the high confidence level that decision makers need.

**T**HE CLARREO VISION FROM THE NATIONAL RESEARCH COUNCIL DECADAL SURVEY. A critical issue for climate change observations is that their absolute accuracy is insufficient to confidently observe decadal climate change signals (NRC 2007; Trenberth et al. 2013; Trenberth and Fasullo 2010; Ohring et al. 2005; Ohring 2007). Observing decadal climate change is critical to assessing the accuracy of climate model projections (Solomon et al. 2007; Masson and Knutti 2011; Stott and Kettleborough 2002) as well as to attributing climate change to various sources (Solomon et al. 2007). Sound policymaking requires high confidence in climate predictions verified against decadal change observations with rigorously known accuracy. The need to improve satellite data accuracy has been expressed in ▶

Detail of CLARREO (red orbit track) obtaining matched data to serve as reference intercalibration for instruments on a polar orbiting weather satellite (green track). For more information see Fig. 6.

# Intercalibration to CLARREO for Climate Change Accuracy



Intercalibration of 30 to 40 instruments in LEO and GEO orbits

# Economic Value of Climate Observations



Environment Systems and Decisions  
Formerly The Environmentalist  
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## Value of information for climate observing systems

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### Abstract

The Interagency Working Group Memo on the social cost of carbon is used to compute the value of information (VOI) of climate observing systems. A generic decision context is posited in which society switches from a business as usual (BAU) emissions path to a reduced emissions path upon achieving sufficient confidence that a trigger variable exceeds a stipulated critical value. Using assessments of natural variability and uncertainty of measuring instruments, it is possible to compute the time at which the required confidence would be reached under the current and under a new observing system, if indeed the critical value is reached. Economic damages (worldwide) from carbon emissions are computed with an integrated assessment model. The more accurate observing system acquires the required confidence earlier and switches sooner to the reduced emissions path, thereby avoiding more damages which would otherwise be incurred by BAU emissions. The difference in expected net present value of averted damages under the two observing systems is the VOI of the new observing system relative to the existing system. As illustration, the VOI for the proposed space-borne CLARREO system relative to current space-borne systems is computed. Depending on details of the decision context, the VOI ranges from 2 to 30 trillion US dollars.

*Electronic supplementary material*

The online version of this article (doi:10.1007/s10669-013-9451-8) contains supplementary material, which is available to authorized users.

**Keywords** Value of information – Climate observing system – Social cost of carbon – DICE – CLARREO

## Journal of Environment, Systems, and Decisions

Cooke et al., 2013

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[/article/10.1007/s10669-013-9451-8](http://link.springer.com/article/10.1007/s10669-013-9451-8)

# Results and Sensitivity to Assumptions

## World Wide Economic Benefits

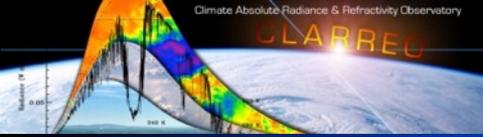
Parameter Change	CLARREO/Improved Climate Observations VOI (Trillion US 2015 dollars, NPV) 3% discount rate
Baseline*	\$11.7 T
BAU => AER	\$9.8 T
0.3C/decade trigger	\$14.4 T
2030 launch	\$9.1 T

\* Baseline uses 0.2C/decade trigger, 95% confidence in trend, BAU => DICE optimal emissions, 2020 launch

- Delaying launch by 10 years reduces benefit by \$2.6 T

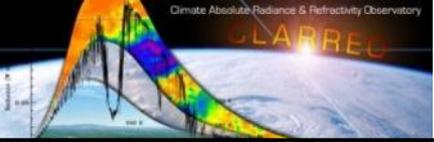


Each year of delay we lose \$260B of world benefits



# 2013 Progress: Instruments

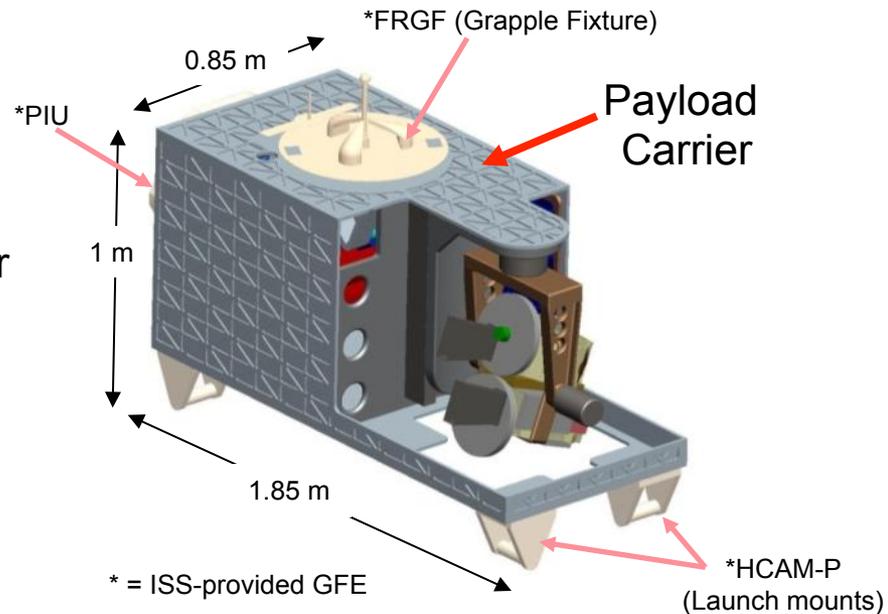
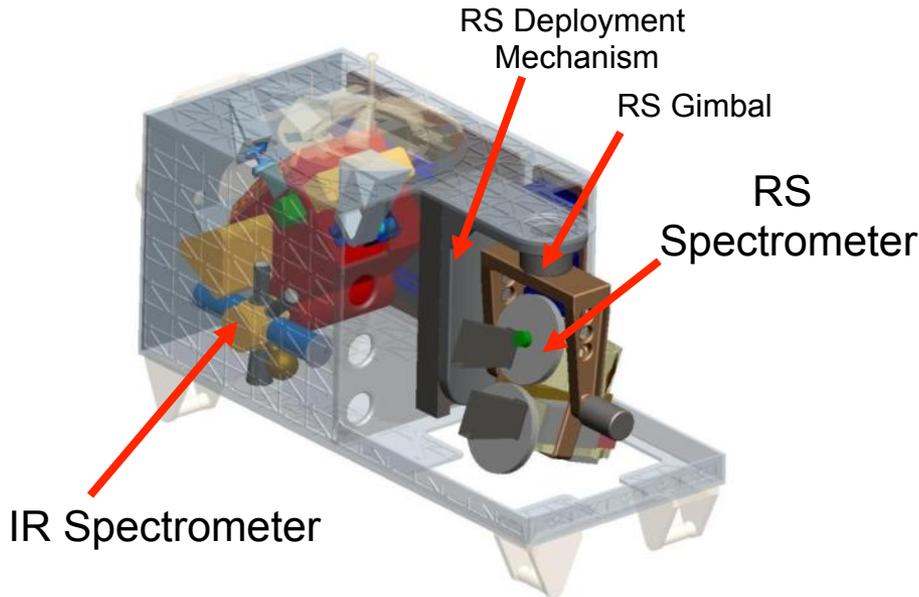
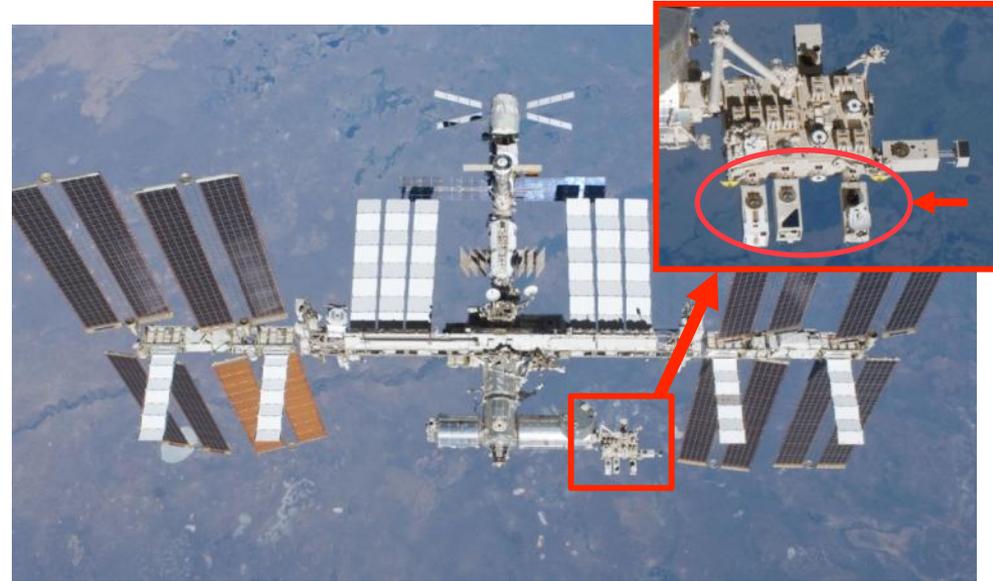
- UW Instrument Incubator Program (IIP) demonstrated space environmental testing to reach TRL-6 on their CLARREO prototype infrared (IR) interferometer
- LaRC IR Calibration Demonstration System (CDS) held successful NIST peer review: now within a factor of 2 of CLARREO requirements with next step to implement small nonlinearity corrections
- CU LASP IIP successful high altitude balloon flight (30km) of their CLARREO prototype reflected solar (RS) spectrometer with solar and lunar views
- GSFC RS CDS held successful NIST peer review, and participated in Landsat ground calibration campaign. On schedule for their successive accuracy steps to CLARREO levels.

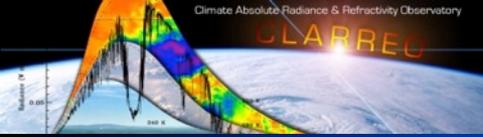


# ISS Mission Concept



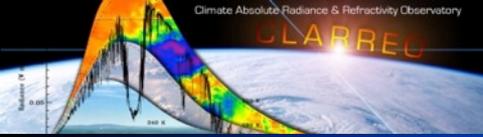
- Selected the Japanese Experiment Module Exposed Facility (JEM-EF) for this study
  - L/V, installation and JEM-EF interfaces defined and provided by ISS
  - Other ISS locations viable, but ram-side of JEM-EF is optimal for maximizing viewing opportunities
- Dual-instrument payload approach demonstrated by NRL's HREP





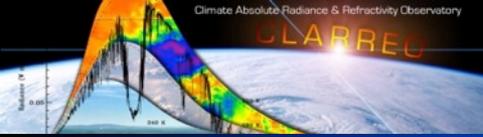
# 2014 Directions

- Extend the science understanding of CLARREO requirements
- Support the next Decadal Survey
- Educate the world on why CLARREO is a critical part of any climate observing system
- Continue to reduce mission costs and risks



# 2014 Key Tasks

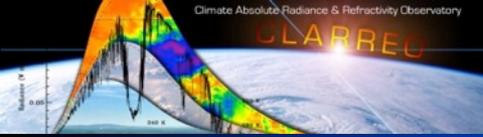
- Key journal papers we still need to publish
- Refining CLARREO requirements as a function of wavelength using new science studies in combination with IIP and CDS instrument calibration studies
- Instrument Design sessions to look at smaller, lighter, less expensive instrument designs
- Summary Report for CLARREO web site and for background support of decadal survey white paper
- Decadal Survey schedule and White Paper



# Decadal Survey Schedule

- NASA/NRC negotiating terms of study now
  - missions as in the last decadal survey? likely NRC preference
  - science topics and priorities? likely NASA preference
  - white paper content may or may not be set in study terms
- Expected selection of study members in spring 2014
- Early meetings of committee in summer 2014
- Expected call for White Papers: Jan 2015
- Expected due date for White Papers: June 2015
- Final report due out in 2017





# Presentation & Team Discussion of 2014 Tasks

## Thursday Morning (1 hour)

